MONOLITHIC DOME INSTITUTE™

Free Information

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The Monolithic Dome

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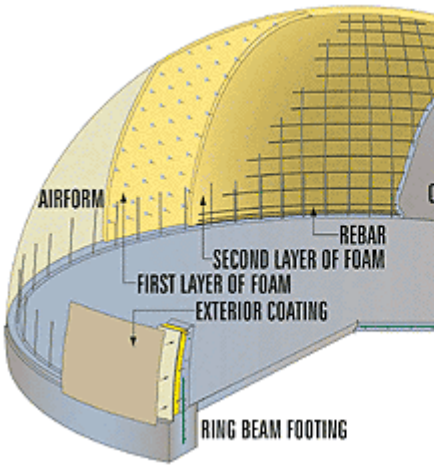
The Monolithic Dome

by David B. South and Freda Parker
May 8, 2007



What is a Monolithic Dome?
Simply defined, the Monolithic Dome is a super-insulated, steel-reinforced concrete structure that can be designed for virtually any use: office or business complex; school; church, synagogue or temple; gymnasium or sports arena; theater or amphitheater; airplane hangar; factory; bulk storage facility; house or apartment complex; military installation, etc.

What makes a Monolithic Dome a better structure and a better buy?
Advantages of a Monolithic Dome fall into three general categories: Economy, Security, Aesthetics and Comfort.

- **Economy in Construction** - Generally, the construction cost of a Monolithic Dome is le conventional building of the same size with similar fittings and fixtures. A streamlined cc the use of only four major ingredients contribute significantly to the dome's economy. Tl ingredients or materials are an Airform, polyurethane foam, rebar and concrete.

An Airform is an inflatable fabric structure, made of PVC coated nylon or polyester fabrics. Whe determines the shape and size of the finished building, and it remains on the structure as its rc

In the construction of a Monolithic Dome, a thickness of polyurethane foam is sprayed on the i Airform. Polyurethane foam is a superior insulator. When sprayed in place, it expands to thirty sets in seconds and fills every nook and cranny, completely sealing a structure. This foam is vi forms its own vapor barrier and adds structural strength.

Rebar is a steel bar with ridges that is used to strengthen concrete. In Monolithic Dome constru that will hold the rebar are placed into the foam, following a pattern predetermined by the dom in the construction of bridges, tunnels and roads, rebar reinforces the dome's concrete.

Concrete used in the building of a Monolithic Dome is called Shotcrete. It's a special mix of con applied to a specific thickness, depending on the dome's size. Shotcrete covers the foam and e the inside of the dome. *Click here to view an illustration of the construction process.*

The construction of a Monolithic Dome is not restricted by either time or most weather conditio the work takes place inside the inflated Airform. Generally, construction can continue around-t snow, eliminating costly work stoppages.

- **Economy in Operation** - Every structure requires care. But Monolithic Domes usually r maintenance because there's less potential for problems. The dome's curvilinear design, building process and its superior materials keep maintenance to a minimum.

Moreover, a Monolithic Dome ages better than do most other types of structures. Virtually una weather, termites, mold or mildew, the dome has a lifespan of not just years, but centuries.

Monolithic Domes are energy-efficient. They are super insulated with polyurethane foam sandw Airform on the outside and concrete on the inside. Thus, they use less energy for heating and

- **Security** - Monolithic Domes have a proved ability to survive tornadoes, hurricanes and therefore meet the Federal Emergency Management Agency's criteria for providing near- During a natural disaster, a Monolithic Dome protects its occupants from injury or death

A Monolithic Dome provides fire protection as well. If a fire attacked the outside of a Monolithic damage the Airform and even melt the foam, but the concrete would survive, and the fire woul

Tests conducted by the Monolithic Dome Institute have shown that domes can easily tolerate s hazards, such as rifle fire and small explosives. They make suitable, safe housing for military p equipment.

- **Aesthetics and Comfort** - Whether its lines are straight or curved, any structure appea unattractive when it's first built and unenhanced. But just as enhancements can soften a lines and corners, they can do the same -- often more easily -- for the gracefully curved

As for the interior, the uninterrupted openness of a Monolithic Dome lends itself to a myriad of

Choosing a Profile and Shape
The profile of a dome determines the size of its surface area or dome shell, and the amount of significantly affects construction cost. In other words, the more surface area there is, the more

Hemisphere or Oblate Ellipse?

In a dome that is a hemisphere, the area of the floor is equal to pi (3 the radius squared or pi X radius X radius. The surface area of that h X pi X radius squared. So, the surface area of a hemisphere dome is its floor area.

But most of us live only in the bottom eight feet of a structure. Some us may not be what we want or need. In that case, we might conside

An oblate ellipse may better suit us. It can save a considerable amount of square footage of the dome shell and still provide us with virtually the same amount of floor or living area.

For that reason, most of the homes Monolithic designs have an oblate ellipse profile. That includes two-story domes; they go straight up and are then topped with an oblate ellipse.

Big Domes
When we design big domes with diameters of at least 200 feet, we have to be even more cogn Consider a dome that is 200 feet in diameter and 50 feet in height. That's a great dome! Its su 39,270 square feet; its floor area equals 31,416 square feet. So, the surface area is only 25 pe floor area. We have used the least amount of materials to build this dome, but we have given amount of usable square footage.

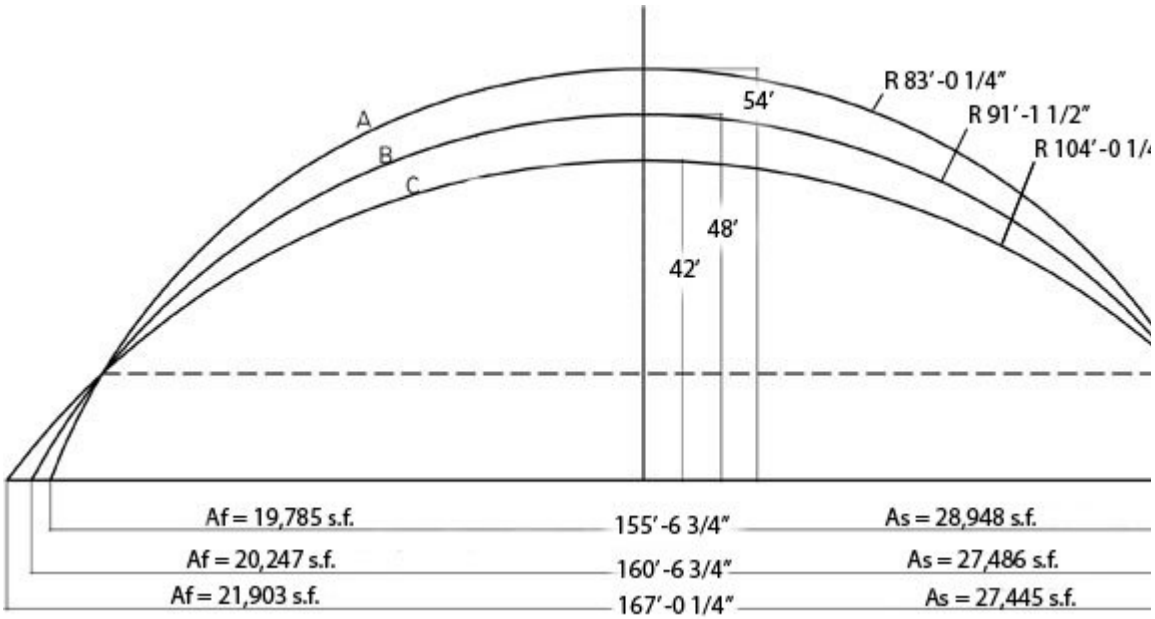
Now consider what happens when we keep the diameter at 200 feet but raise the height and c 200' X 67.6'. Its floor area remains at 31,416 square feet, but its surface area increases to 45, Obviously, such an increase affects price and is not something you want to do if there is no ne

And here's what happens if we design that same dome as a hemisphere, 200' X 100': floor are feet; surface area = 62,832 square feet.

An Appropriate Profile
Sometimes people want a dome with a profile that is not appropriate to their needs. For exam hemisphere dome is not a good choice for a church. To enclose its floor area, you must build 6 surface area! A church has no practical use for all that space above the congregation.

On the other hand, that very same hemisphere is a most appropriate choice for a bulk storage storing fertilizer, for example, you want and need all that upper space. You might even conside storage dome with an integrated stemwall of twenty, thirty or forty feet and topping it with a h

We have illustrated three domes, each with exactly the same amount of floor area below 14 fe
has a different footprint and a different surface area. It's important that dome buyers understa
so they can get the maximum benefit for their money

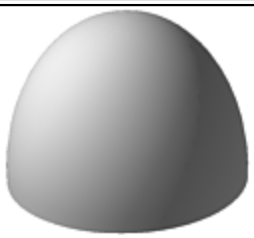
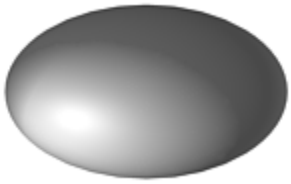


At Monolithic, we are more than happy to review the geometry of any project.

Shapes

Here are most of the pure geometric shapes we use in designing the Airforms that are inflated
Domes. These shapes are shown individually. But they can be intersected with each other to pr
combinations. And their connections can be smoothed to better define the sculptured shapes. I
regular shapes, others can be airformed as well.

	Perspective	Top	
Low profile spherical segment: This is the most efficient shape to cover the greatest amount of floor space. Especially useful for large domes.			
Hemisphere: Surface area is double the floor area. Useful for high volume storage buildings and smaller structures, such as homes.			
High profile spherical segment: The most volume for the least floor area. Ideal for water tanks, storage buildings, unique looking homes and golf course club houses.			

Oblate ellipsoid: Very efficient for single floor structures, such as a home or school. Walls have maximum vertical slope vs structure size.			
Prolate ellipsoid (Long Axis Vertical): Mostly useful for bulk storage. It is very tall vs its footprint. Extremely strong for an underground or buried building.			
Prolate ellipsoid (Long Axis Horizontal): This dome literally leans out from the floor level before curving over the top. Elliptical base creates a very unique space.			
Torus: Not as space efficient as a dome, but it has some fun applications, i.e. a home with a center courtyard or garden.			

FAQs about Monolithic Dome shapes

1) Since the center section is not constructed in a torus, is it less expensive to build?
Actually, no. The dome curves in on itself again to make the tube, thereby increasing the sur shell.

2) What is the usual size of a torus and have you ever built one? *A common home size is 66 fe 32-foot diameter center section. It definitely can be much larger. So far, the torus has failed Monolithic Dome of equal size is about the same price.*

3) What is the maximum height at the center of an oblate ellipsoid style dome? *An oblate ellip for homes and one-story buildings. It brings the height of the dome down; but the walls at th vertical so it provides more shoulder room. In general, an oblate ellipsoid should not have a axis ratio greater than 1.45. Consider a 32-foot diameter dome. The major axis is 16 feet. Di minor axis is 11 feet.*

If we wanted the building to be two-stories high, we would put a 7-foot or 8-foot stemwall u

dome for a total height of 19 or 20 feet. The Oberon plan ("Dome Living: A Creative Guide fo Monolithic Dream Home", pp. 64-67) is an oblate ellipsoid, 32 feet in diameter and 12 feet to one-story home with one, two, three or even four bedrooms.

4) The prolate looks as though it may have better interior feel and window options. Am I seein *Sometimes a prolate fits the lot better. Rarely does it make the windows or shape better. Mo on paper; but in reality, you cannot see anything but a small part of it from the street or ins benefit to the prolate, except for site considerations. Eye of the Storm has the long axis para therefore more beach can be seen from the house. The house still looks circular from the bea circular from within. It just has more exposure to the ocean because it is a prolate. The prol square foot. It takes more material to enclose a smaller space than a traditional circular sh*

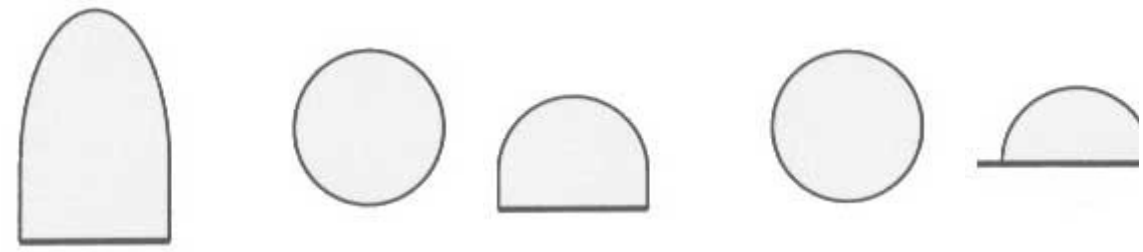
5) Are profiles other than the circular and elliptical available? *Yes -- we can do cones, cylinder hyperbolics, and some sculpted shapes. Air tends to blow round, therefore at least one dime must be round. The only limitations are that it must be inflatable and engineerable.*

Dome Variations/Configurations

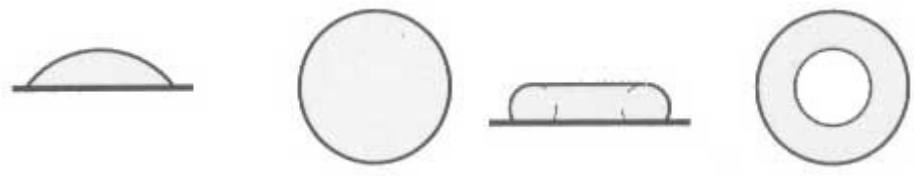
These design concepts have been approved as feasible and reasonable for our use.

Dome Profiles:

Oblate Ellipsoid **Oblate Ellipsoid with Stem Wall** **Tall Prolate E**

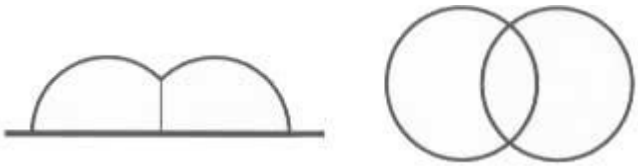


Tall Prolate Ellipsoid with Stem Wall **Half Sphere with Stem Wall** **Half Sphere**

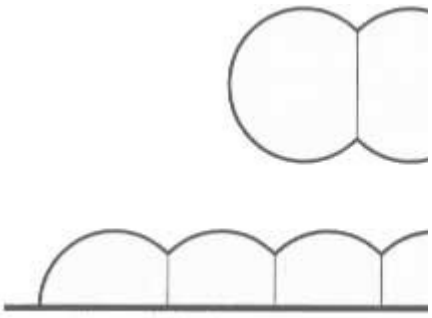


Low Profile Sphere **Torus**

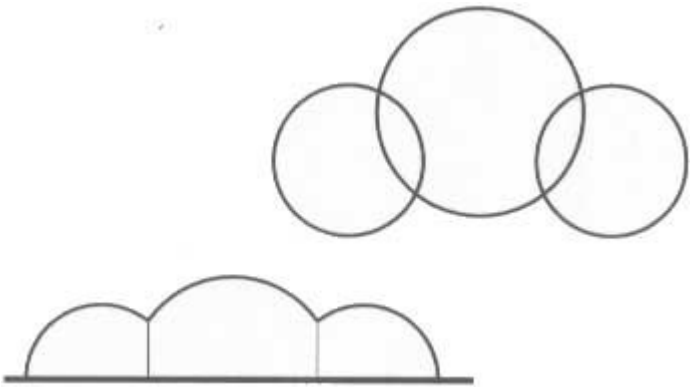
Combinations:



Double Dome



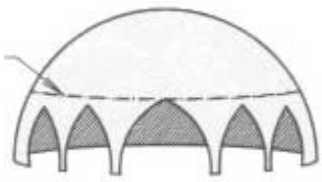
Caterpillar



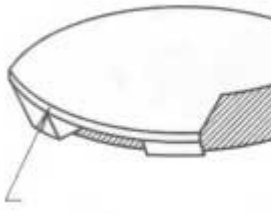
Triple Dome

Openings:

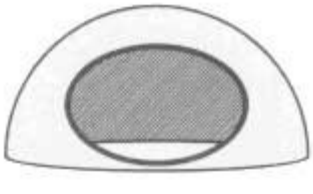
Continuous horizontal reinforcing beam. 300' diameter limit.



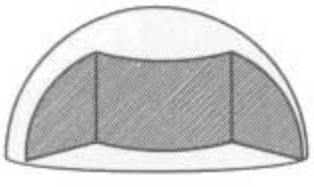
Design for column shear and bending.



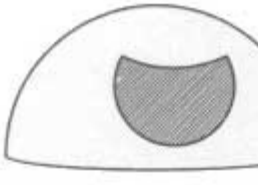
Continuous compressi at bottom.



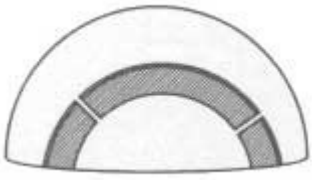
300 ' diameter limit



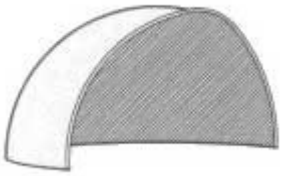
200' diameter limit



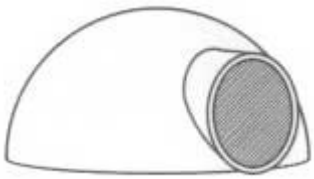
300' diameter limit



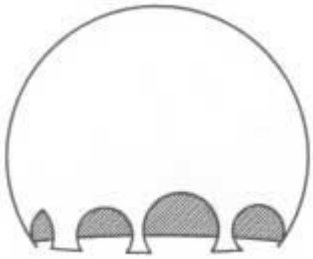
Must have connecting ribs, 200' diameter limit

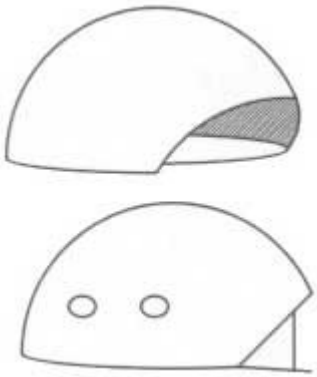


Bandshell (1/4 sphere)150' -- 200' diameter upper limit.



Eccentric opening shapes.





It is better to continue shell at base-- at the tension zone of shell.

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- The Road to a Home
- The Monolithic Dome Info Pak -- Informational DVD
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- True Cost of a Dome
- Why Build a Concrete Dome?
- Mapping It Out-- Monolithic Domes Cover the World

- *Design Ideas for the Monolithic Concrete Home* by Architect, Frederick L. Crandall
- Monolithic Dome Shapes
- Dome Variations/Configurations
- Airform Dynamics

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Building Survivability: The Strength of the Monolithic Dome

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The following information was compiled by Dr. Arnold Wilson, a leading engineer in thin shell concrete construction.

The Monolithic™ Dome is the most disaster resistant building that can be built at a reasonable price without going underground or into a mountain.

A wind of 70 miles per hour blowing against a 30 foot tall flat walled building in open flat terrain will exert a pressure of 22 pounds per square foot (see sidebars). If the wind speed is increased to 300 miles per hour the pressure is increased to 404 pounds per square foot (psf). Wind speed of 300 MPH is considered maximum for a tornado. It is far greater than that of a hurricane.

Cars can be parked on 100 psf. The side pressure on the building could equal the weight of cars piled 4 high. No normal building can withstand that much pressure. Many Monolithic Domes are buried up to 30 feet deep. They must withstand pressures up to 1 ton per square foot (2000 psf)].

Against tornado pressure a Monolithic™ Dome 100 feet in diameter, 35 feet tall would still have a safety margin of nearly 1½ times its minimum design strength. In other words, the stress created by the 300 mile per hour wind would increase the compressive pressure in the concrete shell to 1,098 psi. The shell is allowed 2,394 psi using design strengths of 4,000 psi.

The fact is the Monolithic™ Dome is not flat and therefore never could the maximum air pressure against it of 404 pounds per square foot be realized. Neither is the concrete only 4,000 psi. It is always much greater. The margin of safety is probably more like three or four.

Concrete Dome Wind Analysis

Example 1

Commercial building 30 feet high in exposure C (most severe exposure in open flat terrain). Using design wind pressure from UBC 1985 Edition, section 2311.d, of 70 MPH. V = 300 MPH.

p = Ce Cq Qs I
I = 1.0 (Commercial Building)
Qs = 13psf (pressure from wind)
Ce = 1.3 (building height 30 ft. - exposure C)
Cq = 1.3 (method 2)

Therefore p = (1.3) (1.3) (1.3psf) (1.0) = 22psf

Example 2

Assume same building and same exposure but with wind speed of 300 mph.

Preference: Finte, Mark, Handbook of Concrete Engineering; Nan Nostrand Reinhold, 1974.

p = 1/2 Cs Ca Cg P Vh2 (H/h)2/alpha

Assume everything is constant except the wind speed.

p = C Vh2 = 22psf for V = 70 mph (example 1).
Therefore C = (22) / (70)2 = 0.00449
Then p = (0.00449) Vh2 for V = 300 mph; p = 404psf

The maximum concrete stress in dome 100 feet in diameter by 35 feet high with p = 400psf is 1,098psi compression. From the "Concrete Dome Seismic Analysis" example we see the allowable stress is significantly higher at 2,394 psi.

Conclusion

The forces caused by wind and earthquake on a concrete dome generally do not control the design. Domes are very strong and durable and in a realistic situation would probably still be standing when all conventional structures had failed.

The Monolithic™ Dome at Port Arthur, Texas has now been hit by three hurricanes. A hurricane does not exert enough pressure on a dome to be even noticed. As shown above the dome can very easily withstand the stresses of a tornado.

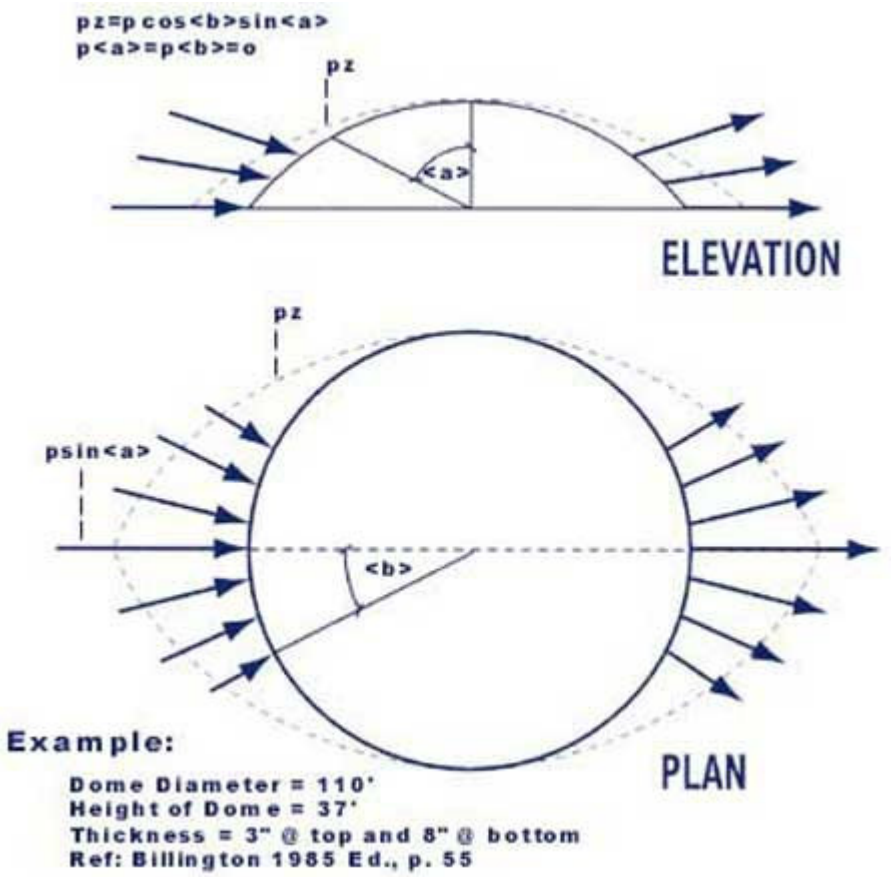
However, debris carried by a tornado could cut the surface membrane. If the debris contained a large timber or metal object, it might be possible if conditions were just right to put a puncture into the dome. But the puncture would be very local and would certainly never cause serious collapse of the dome. Possibly damage to the doors or windows may occur if there was a rapid decompression caused by the tornado.

Wind Speed	Pressure
70 mph	22 psf
100 mph	50 psf
150 mph*	100 psf
300 mph**	404 psf

*Force 5 hurricane (worst)
**Force 5 tornado (worst)

For most Monolithic™ domes the likely disaster will be earthquake. The worst areas in the United States are listed as seismic zone 4. From analysis (see "Concrete Dome Wind Analysis") it is easy to see that earthquake forces do not even approach the design strength the Monolithic™ Dome is built to withstand under normal every day usage. It would take an external force many times as large as the earthquake to approach the design strength of the concrete itself.

Concrete Dome Seismic Analysis



Membrane Forces:

N<a> = - apk1 cos<b>
N<ab> = - apk2 sin<b>
N<b> = - apk3 cos<b>

Seismic Force (UBC 1985 Edition)

V= ZSICKW (Formula for the total design lateral force)
Z= 1.0 Zone IV (Seismic Zone Factor)
CS= 0.14
I= 1.5 (Importance Factor = Hospital)
K= 2.0 (Unusual building such as Dome -- conservative)

Therefore: V = (1.0) (1.5) (0.14) (2.0) W = 0.420W -- Note: V = 0.14W for normal shear wall building!

V = (0.420) (100) = 42.0 psf (pounds/square foot) -- one square foot of shell 8” thick weighs 100 lbs. The value of p = V = 42.0 psf.

For demonstration purposes assume p = 60 psf. This represents earthquake forces in excess of the most sever code requirement by a factor of 1.4.

Maximum stress due to N<b> is -64.8 psi; N<a> is -70.6 psi. Maximum bending moment is 909.3 lbs - ft/ft.

For a vertical live load of 40 psf in addition to the dead load of the shell the following stresses and moment are obtained. Maximum stress due to N<a> = -82.5psi; N<b> = -70.7 psi or .146.5 psi. The maximum bending moment is 1,588.0 lbs-ft/ft.

The maximum allowable compressive force in the concrete is: fc = 1.33 (0.45) (4000psi) = -2.394psi. This is many times greater than the -70.6psi needed.

Conclusion

The forces caused by a major earthquake are considerably less than normal provided for when a dome is designed for nominal vertical loads.

Nuclear fallout is another disaster consideration. It is interesting to note that the only structure left standing near ground zero at Hiroshima was the concrete skeleton of a dome. Certainly the Monolithic™ Dome would be superior to most buildings if a nuclear fallout condition occurred. Rain would tend to wash the radiation off the building much better than conventional buildings.

Generally the Monolithic™ Dome is quite tall. Radiation strengths are inversely proportional to the square of the distance from the source. The roof of the Monolithic™ Dome would hold the radiation further from the occupants than many other structures. Also concrete itself is a good absorber of radiation. The concrete Monolithic™ Dome would greatly reduce the effects of fallout on the occupants.

It is interesting to note that German thin shell structures stood up to allied bombing in the second world war better than most other structures. When a bomb would hit a thin shell it would either bounce off their tough resilient exterior or it would puncture a hole through.

Since there are no single components that carry large loads, there is nothing that can be knocked down like a beam or a column. Therefore repair was a simple patch to cover the hole that was made when the bomb would go through.

"Thin Shell" is the generic name for a Monolithic™ Dome.

This information was compiled by Doctor Arnold Wilson, a leading engineer in thin shell concrete construction.

Related Links:

- Building Survivability (Spanish Translation PDF)
- Fire Sprinkler Systems in Monolithic Domes
- Liquefaction and Earthquakes
- Safe Room or Safe Home?
- A Monolithic Dome Indestructible Fire Station
- The Monolithic Dome -- Informational DVD or VHS
- Why Build a Concrete Dome?
- Monolithic Dome Survives Engulfing Flames of California Wildfire
- Think Round
- Monolithic Dome Home Survives May 4th Missouri Tornado
- Surviving Tornadoes and Hurricanes
- What is a Disaster?
- I Survived a Disaster
- Never Use Steel Fibers Instead of Rebar in a Monolithic Dome

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Antiterrorism Buildings

July 23, 2003

Monolithic Domes can withstand terrorist attacks better than most conventional buildings.

by David B. South, President of the Monolithic Dome Institute

Thin shell concrete structures stand up to allied bombing

In 1976 I received a report from a German engineer stating that, during World War II, thin shell concrete buildings faired much better than other structures. I had hired him to engineer a dome in Germany and he sent me the report unsolicited.

He further reported that during bombing incidents-- if thin shells took a direct hit-- either the bombs ricocheted off the structures and exploded away from the buildings or they penetrated the shell and went off inside.

In either case, the bombs did not bring the buildings down. If the explosive created a hole in the shell, patching the damage was not difficult and cleanup and remodeling could be safely done inside.

This report intrigued me. It came at a time when my brothers and I first started building and promoting Monolithic Domes. Further checking with our thin shell engineer revealed that a three-inch-thick, concrete thin shell could withstand more of a bomb blast than a twelve-inch-thick, highly reinforced, concrete straight wall.

The Monolithic Dome

Click Here

The Monolithic Dome is a concrete thin shell with a three-inch layer of urethane foam covered by a fabric on its exterior.

It is also quite easy to apply another layer of reinforced concrete over the exterior of the fabric. This additional layer not only protects the fabric, but provides armor plating for the already disaster resistant Monolithic Dome.

Obviously, our modern-day thin shell -- the Monolithic Dome -- can be constructed to be even stronger, tougher and more resistant to attack than the thin shells of the past.

Monolithic Domes and surviving terrorist attacks

Terrorist bombing attacks are most often directed against people inside a building. Such attacks often include blowing up a truck parked in front of a building or ramming into structures and detonating explosives. The Monolithic Dome can better withstand these types of attacks than almost any other type of building.

An engineer can demonstrate that any kind of pressure against a dome rapidly dissipates around a curve. But pressure against a flat surface concentrates in the center. This physical principle is one of the reasons why domes are far superior in surviving a blast.

Biological Containment

Biological containment by a Monolithic Dome is inherent. Because they are air tight structures, Monolithic Domes offer major protection from gas, radiation and bio-hazards. This is especially important for schools, military command centers and other large capacity buildings.

Withstanding small arms and direct fire weapons

Monolithic Domes can protect occupants from most indirect fire weapons, as well as small arms fire and many other direct fire weapons. We have tested this on our own buildings.

Click Here

This protection capability of the Monolithic Dome can be further enhanced by covering the Airform with concrete. The concrete-foam-concrete sandwich is the best protection against weapons fire.

Monolithic Domes outlast rampant fires

Click Here

The Monolithic Dome is as fire safe as a building can be made. Only what is carried into the structure can burn. Much of the damage done to cities during World War II was caused by fires which were seeded by bombs and grenades. These fires would not have compromised the security of the Monolithic Dome.

Military Applications

A quick study of Monolithic Domes can show that they are the logical buildings for most military applications. Their cost of construction is reasonable. They require less materials to construct and are generally faster to build than conventional buildings. Energy reduction is usually 50% or more. They are permanent. And they are easy to lock down and defend--hostile entities would find it very difficult to break through a Monolithic Dome.

More importantly, Monolithic Domes can withstand natural and man-made disasters. They make excellent munition storages-- reducing the risk of detonating the contents by hostile fire. If the contents DO detonate, the Monolithic Dome can protect the surrounding area from the explosion.

The government invests billions of dollars in military and research equipment. It would make good financial sense for these tanks, planes, automobiles and *even the space shuttle* to be stored in Monolithic Domes instead of metal tents.

The Monolithic Dome is the only building that can be built at a reasonable price to meet FEMA's guidelines for a building that provides near-absolute protection.

Related Links:

- Building Survivability
- Wind, Water and Monolithic Domes
- Liquefaction and Earthquakes
- DuPont's Mississippi Gulf Coast Facility Builds A Monolithic Dome Hurricane Shelter
- A Monolithic Dome Indestructible Fire Station

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Passing the Bullet Test

The strength and durability of Monolithic Domes

July 1, 2004

by David B. South

Enlarge

As they say on TV, "Don't try this at home." Don't shoot holes in your home with a 30-06 caliber rifle. In the photograph on the left Gary Clark is firing on one of our 32-foot Monolithic Dome storage buildings. He is firing from very close range, nearly perpendicular to the dome. He shot one shell into each of two of our 32-foot diameter shops. The first shell entered through the Airfrom leaving a hole in it about the size of a pencil. The bullet disintegrated inside that hole. We dug out the bullet later, and it was totally flat. The bullet fired from a 30-06 was a 180 grain hunting bullet with a full copper jacket. This is the type of shell that was used in World War II in the Garand Rifle. It is far more powerful than today's modern M-16 bullets.

The second dome when hit with the 30-06 rifle had a small piece of concrete approximately the size of a fist fall off the wall, but the bullet did not penetrate. This experiment shows that the Monolithic Dome can withstand a substantial amount of rifle fire. Certainly, it would withstand any pistol fire or anything smaller than a heavy duty 30-06 at a point blank range, and perpendicular.

Rifle Fire vs. Projectiles

Enlarge

Any projectile fired at a surface will dramatically loose its effect at an angle. Obviously a Dome presents a far smaller area perpendicular to the plane of any projectile than any other structure.

On the other hand, rifle fire is not the same as a two by four doing a hundred miles an hour. The mass of the two by four is extraordinary. Nevertheless, a four-inch reinforced concrete wall will stop that two by four. Very few Monolithic Domes have less than four inches of concrete in the wall section. The urethane foam on the outside will also mitigate the impact of a projectile, be it large or small. The foam will also absorb a large amount of the energy, especially off a projectile with a large surface such as the two by four.

Enlarge

The fact that the urethane is applied over the concrete and the concrete of a Monolithic Dome is stronger than normal concrete, the chances of penetration become extremely small. Now, add that to the fact that the dome is curved. A curved surface, especially curved in two dimensions as the dome is, changes the dynamics of a force impinging on the dome dramatically. The force immediately is directed around the dome rather than concentrated at the point of impact. This is most especially true of something like a two by four -- less true with something like a rifle bullet. So, not only do we have the other things going for us, the compound curve adds a huge amount of value in repelling a projectile. In fact, the projectile really doesn't become a problem at all to a Monolithic Dome except at the doors and the windows.

Experts have tried to calculate what would happen if an eighteen wheeler flew through the air and landed on a Monolithic Dome. The consensus has been that if you can you can get the truck airborne, a Monolithic Dome might crack but would certainly not cave in. A more likely scenario would be a car. An automobile does not have enough mass or energy from a tornado

to be a serious factor when and if it landed on a Monolithic Dome.

Enlarge

If you are lying in a bed in your bedroom and you hear the onset of the tornado, it's a good idea to roll out of the bed and move up against the dome wall away from what could be flying glass if it shatters. The dome can handle tornado pressure both inside and outside so the loss of one window just means there is some air blowing around outside. If you lose windows on both sides of the house the wind can blow through the house and you may lose some of your possessions, but if you will stay up against the concrete wall you will be as safe as reasonably feasible.

There is peace of mind that comes from being in a Monolithic Dome during a storm. You quickly realize you might lose the dog house, the trampoline, the carport, and even the porch, but at least the dome you are in will survive. It's also comforting to know that you don't have to stay up all night watching television to make sure the tornado watch is cancelled before going to bed. The risk is definitely minimized within a Monolithic Dome.

Each person has to decide what is an acceptable risk for themselves. In the past, conventional construction did not offer much in the way of tornado protection without spending a lot of money for a separate structure for the sole purpose of providing protection. On the other hand, the Monolithic Dome provides near-absolute protection, in most cases, without spending any extra money. In fact, it generally will save the cost of the structure in energy savings.

Again, do not try this at home.

Related Articles:

- The Monolithic Dome
- Monolithic Dome Construction Process
- From Toothpicks to Trailblazing
- Who We Are
- The Monolithic Dome -- Not a Square Idea
- The Road to a Home
- The Monolithic Dome -- Informational DVD or VHS
- Building Survivability
- Think Round
- Surviving Tornadoes and Hurricanes

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Biological Containment

An Evaluation of the Monolithic Dome Construction Method for Biological Containment Structures

by Noel Neighbor, M.S., University of Arkansas, Fayetteville, Arkansas, and David B. South Monolithic Constructors, Italy, Texas.

Calamaco cold storage

Abstract

A Monolithic Dome was built as a residential structure using a previously developed Airform technique. The building consisted of an outer airtight form, polyurethane foam insulation, and reinforced concrete. Except for the Airform kit, locally available materials were used for construction using several alternatives and options applicable to this kind of building. The process and options were evaluated relative to their application for the production of biological containment facilities. It was concluded that the Monolithic Dome building technique is an effective alternative to conventional methods.

Literature Review

Required characteristics of a functional biological containment building have been outlined in several publications over the last 30 years (Kuehne 1973, Phillips 1967, U.S. Department of Health and Human Services 1993, U.S. Department of Agriculture ARS 1991.) Sealed concrete walls, floors, and ceilings have been specified along with directional filtered airflow. Specifications for the sealing of penetrations currently range from statements such as "Penetrations in these surfaces are sealed, or capable of being sealed to facilitate decontamination." (U.S. Department of Health and Human Services 1993) to extensive pressure decay testing procedures which require airtightness to an extreme degree (U.S. Department of Agriculture ARS 1991). In the pressure decay testing requirement, sealing must be so complete that at a beginning pressure of 2" (5 cm) w.g. (water gauge), the rate must not exceed 7% (logarithmic of pressure against time) per minute over a 20 minute time period. This is a difficult standard to attain using conventional building designs and techniques.

The procedures for producing a Monolithic Dome are described in an article by one of the originators of the process (South 1990). A circular concrete footing is first constructed. A fabric form is then attached to the footing and inflated with air pressure. Two to five inches of polyurethane foam are then sprayed onto the inside of the form after which reinforcing steel (rebar) is attached to the foam. Last, concrete is sprayed over the foam and steel (Figure 1). The procedure may be modified if insulation is not desired by using a different kind of Airform and placing the steel and concrete on the outside of the form (South 1995).

Monolithic Domes have potential for extreme airtightness as shown by their use for fruit storage in Stockton California (Anonymous 1990, Schmidt 1989). An atmosphere of 98% nitrogen and 2% oxygen at near freezing temperatures has been maintained in two 230 foot (70 meter) diameter domes to suspend the aging of fruit. Each dome contains 42,000 square feet (3902 sq. meters) of floor space, illustrating that massive airtight structures are possible. The key to the degree of

airtightness is in the urethane foam and the seamless quality of sprayed on concrete.

Construction costs for this kind of structure are relatively low. The Stockton, California domes cost approximately $20.00 per square foot (.09 square meter). For residential use, finished dome costs were estimated in the range of $25.00 to $35.00 per square foot. In industrial use such as the storage of large quantities of fertilizer, it is estimated that domes require 50 percent less concrete, reinforcing, and footing than do conventional walls (South 1991). With the addition of airtight doors, HEPA filters (High Efficiency Particulate Air Filters), airlocks, and the necessary control equipment, the cost of a finished containment structure may be below the usual cost of such buildings due to the savings on the building shell.

High structural integrity is a highly desirable feature of a containment building. It has been estimated that a Monolithic Dome with proper earth sheltering will withstand bomb blasts more effectively than conventional structures (Barbier 1994). One chemical company chose to use a Monolithic Dome to store large quantities of material and makes the following statement: "The strength and stability of domes make them virtually immune to climatic catastrophe, or earthquakes, as well as to fire, or corrosion hazards." (Wood 1995). For environmental reasons, a state highway department uses a dome for salt storage on the basis of the estimation that 80 to 90 percent of environmental problems associated with the use of salt on roads is due to improper storage (Anonymous 1988).

Energy efficiency of building designs should be considered and is high in Monolithic Domes. The R-value of a typical dome is considered to be 35, but may effectively be higher due to the effect of thermal mass (South 1990). The energy saving features of domes are summarized by an architect who states, "Domes embody the virtues of simplicity, economy, and energy conservation, and enclose the maximum amount of space with the least surface area. It is this surface area which consists of building materials, and comprises the exterior skin of the building through which heat is gained, or lost. This is the essence of dome efficiency."

With the exception of the Airform kit, locally available materials are all that is needed to produce a dome. The expertise required to manage the alternative methods of construction may be developed through video tapes and classes taught by experienced dome builders (Neighbor 1995).

Materials and Methods

Generally standard materials and methods of Monolithic Dome construction were used. Variations and options chosen are listed in the following sections.

Airform Kits

The Airform kit was obtained from Monolithic Constructors, Italy, Texas. The kit consisted of a 40 ft. (12 meter) diameter form along with reinforcing steel (rebar) anchors. The form was ordered in the shape of a half sphere with no custom window, or door augmentations.

Polyurethane Foam

Sprayed on polyurethane foam insulation was of a type using a two part process in which Diphenymethane-4, 4'-diisocyanate was mixed with blended polyol resin.

Reinforcing Steel

Steel in the foundation and slab was 5/8 inch (16mm) and 1/2 inch (13mm) grade 40 rebar. In the dome shell 1/2 inch (13mm) and 3/8 inch (9.5mm) grade 60 rebar was used.

Concrete

In the foundation and slab a standard 5 sack (470 pound cement per cubic yard), (214 kg cement per .76 cubic meter) concrete foundation mix was used. Concrete used in the dome shell was a 9 sack per cubic yard (.7647 cubic meter) mix. This was made up of 846 pounds (385 kg) Portland cement, 2182 pounds (992 kg) sand, 394 pounds (179 kg) 3/8 inch (1 cm) maximum diameter gravel, 1.5 pounds (.7 kg) plastic fibers and 4 ounces (118 ml) air entraining agent delivered at a 2" (5 cm) slump ready for the addition of water to pumping consistency. For the final coat of concrete, the gravel was eliminated and sand substituted.

Construction Procedure

The footing and slab were constructed at the same time using a ringbeam configuration for steel in the footing and a grid pattern for steel in the slab. Polyurethane foam was applied in two layers to a total thickness of 3 inches (7.6 cm). Concrete was applied by the shotcrete (wet) process over a period of four days. Each day from 0.5 inch (1.25 cm) to 1.5 inch (3.8 cm) of concrete was added to the structure. This was done by standing on the floor, or from up to three layers of 5 foot (1.5 meter) scaffolding at a maximum distance of 6 feet (1.8 meter) from the nozzle tip to the wall. The design specified the application of at least 6 inches (15 cm) of concrete at the wall base tapering to at least 2 inches (5 cm) at the top of the dome. Following the last application of concrete, blowers were left on for 8 hours and then shut off. The airlock was then left closed for 30 days to allow curing of the concrete.

To provide a smooth finished surface, a layer of cement based plaster was later hand applied and finished. This was primed with water based acrylic latex and finish coated with acrylic latex enamel.

Pressure Testing and Durability Observations

Pressure Testing

Coarse pressure testing was the only pressure testing possible on this project. Deflection of a sheet of builders plastic taped over a window opening was audibly measured as a door was closed. Later after the installation of sealed, non-operable windows, air movement was audibly measured following the rapid closing of an exterior door and the resultant compression of air in the interior of the dome. It was not possible to do a pressure decay test on the structure.

Structural Observations

Twenty-four months following the completion of the dome, observations were made concerning durability. The floor and shell were examined for cracks and the surface of the Airform was checked for deterioration due to weathering.

Testing of Insulation

The dome was tested for the effectiveness of the insulation during winter temperatures. Two 1500 watt electric heaters were run for approximately a month while qualitatively measuring the room temperature.

Results

Closing of a normally gasketed residential door produced pressure sufficient to cause plastic covering a window hole in the exterior of the dome to produce an audibly detectable deflection. During the closing of the door later with permanent windows in place, air could be heard rushing between the door and the jamb for approximately two seconds after the door was shut. Air leaks were small enough in number so that combined with the insulation on the building, only minimal heat was required to keep the dome at close to habitable room temperature (59 to 68F, 15 to 20C) using only the two 1500 watt heaters.

The structure remained sound following completion. No major cracks formed in the dome shell. More cracks occurred in the slab than in the shell. The Airform remained in about the same condition as when new, not showing any noticeable deterioration from the weather.

Discussion

Results of the construction of the dome show that there is potential for this kind of dome to be used successfully for biological containment building construction. As indicated by the results of the door closure testing, the airtightness required for pressure decay testing is nearly achieved after a dome is finished. One of us (Neighbor) has been through the pressure decay testing and sealing process with a conventional building and reports that the degree of airtightness achieved after the initial dome construction was comparably achieved in the conventional building only following days of preliminary leak detection and sealing. Pressure decay testing was beyond the resources available for this project. Had it been reasonable to do more extensive sealing of openings and penetrations, there is a high possibility that the USDA tests would have been passed with minimal effort. Energy efficiency was confirmed in the winter heating of the dome. The lack of major cracks in the shell indicates that the structure is permanent and durable. The lack of noticeable weathering of the Airform indicates that it should last for several years before requiring recoating. Interior wall finishes using paint may be adequate to permit airtightness and cleaning initially, but consideration should be given to the use of a flexible polymer finish to compensate for cracks if they should eventually occur. With the addition of air locks, specialized HVAC equipment, airtight doors, and a small amount of additional sealing of penetrations, this structure could be modified to meet the requirements for containment in Ag BSL-3 construction with much less work than with a conventional building (U.S. Department of Agriculture ARS 1991).

There are several reasons that Monolithic Domes should be seriously considered as assets to any attempts toward ultimate biosafety. Other types of buildings, while able to pass a pressure decay test immediately following construction, would most likely not pass a year later due to settling of foundations and resultant cracks in the containment envelope. Preliminary evidence is that Monolithic Domes will remain structurally stable for extended periods of time. Reinforced concrete combined with the dome shape is extremely strong. There would be much less likelihood of a break in containment due to earthquakes, or severe weather than with a conventional building. The recent terrorist bombings around the world also indicate the need for extreme structural security of any laboratory in which dangerous biological agents are present.

Concern has been raised by some about the risks to domes during construction as a result of power failures. The most critical time appears to be while foam only, or foam and untied rebar are supported by only air pressure. One builder reported that after all of the rebar on a 50 foot (15 meter) diameter dome had been placed and tightly tied, power was down on both a portable generator and the utility company for about half an hour. The dome did not suffer any noticeable damage during this time (Vaughn 1995). This might not have been the case before all rebar was tied, or if the power had been lost later during shotcrete application. The necessity for back-up emergency power is thus indicated during construction.

Potential uses for Monolithic Domes as containment structures are numerous. Small animal research work could be done under conditions which more closely approximate wild outdoor, or agricultural conditions than do isolator cages, or small floor pens. For large animal disease work Monolithic Domes provide walls which may stand the abuse of large animals and offer open spaces needed for exercise. Aerosol testing as applied to the development of defensive devices against chemical and biological warfare agents might be done in large domes. Due to the insulating qualities of the shells, the attaining of high, or low temperatures would be easily accomplished. The strength of this kind of construction would also allow either above, or below sea level altitudes to be simulated through the use of high pressure supply, or exhaust fans.

Since the security offered by Monolithic Domes is unequaled for the amount of money required to produce them, they should be ideal for new research and treatment facilities required by government and health organizations. To produce a structure by conventional methods with as much durability as a concrete dome could require much more than available funding. Although research and health funding is decreasing, the need for affordable containment is increasing. Patients requiring isolation due to antibiotic resistant respiratory infections and those who need to be protected from infection due to immune system disfunction continue to become greater in number. Buildings located in areas away from the general population might be advocated, but it would be more effective to place the treatment centers close to the problems in areas of dense population. An affordable place to house these patients is available in Monolithic Domes.

There are other non-biocontainment applications for Monolithic Domes. Large exercise areas might be built to train athletes, or the military for performance at various air pressures and temperatures. Where large clean rooms are required for medical and electronics parts manufacturing, isolation domes may be an answer as to how to supply hundreds of thousands of square feet of unobstructed, clean, isolated, affordable space. Durable, affordable, energy efficient homes, schools, factories and churches, may also be provided through this technology.

A Little History and A Lot of Photos of Monolithic Dome Storages

(Reprinted in the 1997 Summer Roundup with the permission of the American Biological Safety Association. This article originally appeared in their journal entitled Journal of the American Biological Safety Association.)

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Building Better Provides Tornado Protection

May 12, 2003

by Freda Parker

Safe Room or Safe Home?

A "safe room" is usually a small, interior area in your home, such as a bathroom or walk-in closet, in which you and your family can wait out a bad weather watch or safely stay in during an actual tornado or hurricane. According to FEMA (Federal Emergency Management Agency) to be truly "safe," such rooms must be constructed following FEMA's specifications and standards and must be easily accessible at all times.

FEMA says that if you are building a new home, in most locations you can include a safe room for an additional $2500 to $6000. But FEMA does not give cost estimates for retrofitting an existing home with a safe room, nor does it recommend this as a do-it-yourself project for homeowners lacking construction skills and know-how.

"Nevertheless, it does sound good and relatively easy," says David B. South, Monolithic's president. "And safe rooms *do* work. But are they really the best idea? How livable, how comfortable are they?"

David points out that it's not unusual for a tornado or hurricane watch to last many hours. During a tornado rampage such as we're currently experiencing -- more than 400 twisters in eight days -- that may mean many days of tornado watches, each lasting for four or more hours.

"What if the tornado watch is at night?" David asks. "Can you sleep in the safe room? Can you do anything in there besides just sit and anxiously wait? What's the emotional toll of all that waiting on you and your loved ones? Will you really feel safe in the space usually occupied only by the vacuum cleaner and other household items?

In any case, you will be up all night listening to TV and radio broadcasts, trying to determine if you should run to the safe room, how long you should stay in the safe room and when it is safe to leave the safe room."

The Alternative: A Monolithic Dome Safe *Home*

Because of the way in which it's designed and constructed, a Monolithic Dome ***automatically*** becomes a "safe home." Its steel-reinforced concrete, its rounded shape and its weight make it so.

David says, "Besides being a good idea for anyone planning to build a new home, building a Monolithic Dome home is an especially timely and appropriate idea for disaster survivors who lost their homes. FEMA is encouraging people -- particularly those living in areas prone to tornadoes, hurricanes, floods and earthquakes -- to be safer by building better. And that makes sense. **Wouldn't you rather have an entire home that gives you what FEMA calls *near-absolute protection* instead of just a tiny room?"**

Grants, Loans and Tax Incentives

Government groups, on the local, state and federal level, as well as other organizations offer grants, loans and tax incentives to eligible private citizens, businesses and communities who

want to build disaster-safe structures. FEMA has several programs explained in detail on its website: www.fema.gov. FEMA's website also provides links to other programs, such as *Kauai's Safe-Room Tax Break Program* and the U.S. Small Business Administration's *Pre-Disaster Mitigation Loans for Small Businesses Program.*

A Success Story

In 1995, Hurricanes Erin and Opal severely damaged Mark and Valerie Sigler's home in Pensacola Beach, Florida. The Siglers applied and received a grant through FEMA's *Flood Mitigation Assistance Program* for 75% of *eligible costs*: their Monolithic Dome shell.

"But," says Valerie, "the process was not easy. We had to prove to FEMA that the Monolithic Dome home we planned was worthy of the grant -- that it could withstand hurricane and flood damage." The Siglers did that by organizing an extensive notebook of information, most of which they got directly from Monolithic, about the dome and its advantages.

Valerie says, "We gave them data on all of the dome's advantages -- not just its ability to survive hurricanes, but on how domes can withstand tornadoes, fire, termites, rotting and earthquakes and about their energy efficiency." The Siglers supplemented that information with a list of 35 suppliers and products they intended to use, along with their reasons for their selection: www.domeofahome.com.

Another Alternative

A Monolithic Dome, with all its disaster resistance and sheltering ability, can also be built as an added but separate structure. David South says, "You can build a separate dome that's within easy walking distance of your main house as living quarters for aging parents, a family recreation room, a workshop, a garage, a storage shed -- any number of purposes. Domes come in all sizes and styles. Some are small enough to be transported, and those mainly used as garages or storage sheds can be equipped with an air exchange system.

"Such a shelter," David concludes, "not only provides physical safety when natural disasters strike, but emotional security -- and, if you need or want to sleep through a weather watch -- some necessary comfort."

Related Links:

- What is a Monolithic Dome?
- Monolithic Dome Construction Process
- Concrete and Steel: Complementary Opposites
- Monolithic Dome Home Survives May 4th Missouri Tornado
- The Road to a Home
- The Monolithic Dome -- Informational DVD or VHS
- Dome of a Home Website
- Building Survivability
- Why Build a Concrete Dome?
- Monolithic Dome Survives Engulfing Flames of California Wildfire
- Think Round
- Surviving Tornadoes and Hurricanes
- What is a Disaster?
- I Survived a Disaster?

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Surviving Hurricanes and Tornadoes

Back-to-back hurricanes in Florida catch the media's attention and shine a light on the benefits of the Monolithic Dome

September 1, 2004

by Freda Parker
Photo by Chris Stickney

Dome of a Home is owned by Mark and Valerie Sigler in Pensacola Beach, Florida. This home a spectacular vacation rental. Go to www.domeofahome.com for more information.

Phone calls and inquiries are pouring in to the Monolithic Dome Institute as yet another hurricane threatens Florida. News reporters and television crews are making their way to dome owners in the area. As we see more and more natural disasters, the wisdom of building a Monolithic Dome becomes more apparent. These structures give us absolutely the most protection of any structure that can be built at a reasonable price.

Deaths, injuries and property damage caused by tornadoes and hurricanes can be prevented. That's the primary and most important conclusion FEMA (Federal Emergency Management Agency) reaches in its manual, Design and Construction Guidance for Community Shelters. But this manual doesn't stop there. It not only says that structures strong enough to survive tornadoes and hurricanes can be built, it actually tells people how to do that.

Understandably, FEMA claims the book is a first. Prior to its publication there simply were no known buildings, fire or life safety codes or engineering standards that gave detailed information for the construction of protective structures.

Monolithic's President David B. South agrees. He says, "For years now, FEMA has been studying the after-effects of natural disasters. They have seen so much loss of life and destruction caused by tornadoes and hurricanes that they are now really encouraging people to build homes, public structures and especially community shelters with what they call near-absolute protection, and they are setting a precedent by actually telling people how that can be done."

But exactly what is *near-absolute* protection? FEMA defines its term:

> *Shelters designed and constructed in accordance with the guidance presented in this manual provide "near-absolute protection" from extreme-wind events. Near-absolute protection means that, based on our knowledge of tornadoes and hurricanes, the occupants of a shelter built according to this guidance will be protected from injury or death (P.1-2).*

FEMA has its reasons for calling this protection *near-absolute* rather than *absolute*. The agency says that its knowledge of hurricanes and tornadoes is based on meteorological records and damage investigations of "extreme-wind events," such as tornadoes with wind

speeds of up to 250 mph. Yet, hypothetically, even more severe winds can occur that make absolute protection an impossibility (P.1-2).

"But the fact that people can have near-absolute protection is really important information for schools, mobile home parks -- any community in a high-risk area," says South. "Just think how many lives could be saved, how much property damage could be prevented if every community had at least one school gymnasium, community center or church that could provide near-absolute protection. Tornadoes and hurricanes hit often enough, so it is a goal worth working towards."

Since 1995 FEMA has been receiving reports of more than 1200 tornadoes nationwide each year. Those twisters are categorized on The Fujita Scale according to the damage they cause. The Fujita Scale has a 0-to-5 range, with F0 as a light tornado that might damage roofs and topple young trees. At the other end of the scale, the F5 produces incredible devastation, lifting homes off foundations and turning cars into flying projectiles.

As for hurricanes, FEMA says that about five hurricanes strike our mainland every three years. Two of those five will be major hurricanes creating extensive damage, or at least a Category 3 on the Saffir-Simpson Hurricane Scale. This scale uses a 1-to-5 range, with a C1 as a minimal hurricane and a C5 as catastrophic.

FEMA encourages each community to do its own risk assessment to determine its need for a community shelter and suggests the steps that should be followed in making that assessment. David South agrees and says, "Put in really simple terms, the number one question that a community must answer is, 'Do we live in a high-risk area?' And the question that naturally follows that is, 'Do we want to protect our children and ourselves from potential natural disasters?' The FEMA manual has tools that can help answer such questions."

One of those assessment tools is a "Design Wind Speed Map For Community Shelters." This map presents four wind zones showing which U.S. areas are most prone to tornadoes and hurricanes. With this information, an engineer or architect can select the right design for a particular community. For example, Wichita, Kansas in Zone IV is in the likeliest area for winds of 250 mph, while Rocky Mount, North Carolina in Zone III could have winds of 200 mph. So, each needs shelters that can withstand those velocities (Fig. 2-2, P. 2-5).

Dr. Arnold Wilson

Dr. Arnold Wilson, MDI's Consulting Engineer, elaborated on the importance of the *Design Wind Speed* concept. He said, "The forces on buildings caused by wind are related to the velocity of the wind. Local conditions, such as mountains and valleys or trees or other buildings or open spaces, all affect the wind forces.

"Measurements of wind velocity have been made for many years at many locations, such as airports. By knowing the wind velocity and how it varies with height and location, it is possible to estimate the force that results on a particular type and shape of structure or building.

"When the forces on the building are known, the engineer can then design the building to withstand those forces."

According to FEMA, for a structure to protect its occupants during a high-wind event, it must be designed to withstand the wind's velocity, and it must be constructed with a *continuous load path*.

Dr. Wilson explained this concept as well. He said, "When forces are placed upon a structure by wind or seismic events, the forces are transferred through all parts of the structure through continuous contact between its members.

"In other words, the exterior forces have a continuous load path through joints, connections, beams, columns, walls and slabs until the forces are transferred into the ground."

FEMA points out that the very shape of a structure significantly affects how it weathers a storm. David South agrees and says, "Angels, sharp corners and flat surfaces give the wind something to lift or push against; so, buildings that are smoother and rounded survive better."

What FEMA calls *Resistance to Missile Impact* is also important. To provide near-absolute protection, a building must be able to resist a missile blown into it. That missile could be a brick, a tree limb, patio furniture -- just about anything. But FEMA has determined that if a structure can resist a two-by-four, weighing 15 pounds and traveling at 100 mph horizontally or 67 mph vertically it has the needed strength.

"A Monolithic Dome can do that -- easily," South says. "We had a semitrailer truck, fully loaded with rocks, careen down a hill and smash full force into a Monolithic Dome. It knocked a hole in the shell, but there was no serious penetration -- which means that people inside the dome were protected. But other structures probably would have been leveled and their occupants either hurt or killed."

Hurricanes

FEMA defines a hurricane as "An intense tropical weather system with a well-defined circulation and sustained winds of 74 mph or higher" (P. 3-5). Hurricane winds create storm surge -- gigantic walls of sea water, often carrying debris, that crash against buildings.

Although water produces more pressure against a structure than wind, South says, "A hurricane does not exert enough pressure on a dome to be even noticed. A Monolithic Dome at Port Arthur, Texas has now successfully survived three hurricanes. However, storm-surge debris could cut the dome's surface membrane. Given the right conditions, a large timber or metal object could possibly puncture the dome. But the puncture would be very local and would not collapse the dome."

Dr. Wilson says, "When it comes to disaster survivability, the Monolithic Dome's rounded shape and its steel-reinforced concrete put it head and shoulders above most other structures."

Wilson points out that a wind of 300 mph pushing against a structure exerts 404 pounds of pressure per square foot (404 psf). But Monolithic Domes have been built underground, buried up to 30 feet deep. They withstand pressure up to 1 ton per square foot (2000 psf).

A Comparison of Two Structures

In its manual, FEMA includes much detailed information relating to the design and construction of a building that can provide near-absolute protection. After reviewing FEMA's criteria, both South and Wilson agree that Monolithic Domes meet or exceed each of FEMA's standards. In other words, Monolithic Domes do provide the near-absolute protection that an agency of our federal government now, more actively than ever, is encouraging communities to seek.

In its ***Design and Construction Guidance for Community Shelters*** manual, FEMA details the design of a community shelter planned for North Carolina, but not yet built (Appendix C). This particular community has been hit by hurricanes and is in Wind Zone III, so it can experience winds of up to 200 mph.

We compared the proposed North Carolina structure to the Monolithic Dome gymnasium built in Italy, Texas, a Wind Zone IV area prone to winds of up to 250 mph.

Feature	Proposed FEMA Shelter-- North Carolina	Monolithic Dome-- Italy, Texas
Size	3,600 Sf. Structure is approx. 12' high, 72' long and 50' wide.	17,200 Sf. Diameter of 142 feet. Includes classrooms, auditorium and gymnasium.
Construction Materials	Reinforced Concrete	Steel-reinforced concrete, 6" thick at the bottom and 3 1/2" thick at the top.
Design Strength	Designed to survive winds of up to 200 mph.	Designed to survive winds of up to 250 mph.
Unit Cost Per Sq. ft.	$98.00 (estimated)	$85
Total Construction Costs	$354,000 (estimated)	$1.8 Million

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- Maranatha Church Members Call Hurricane Rita "Eerie"
- Dupont and Katrina: The Category 5 Dome
- Wind, Water and Monolithic Domes
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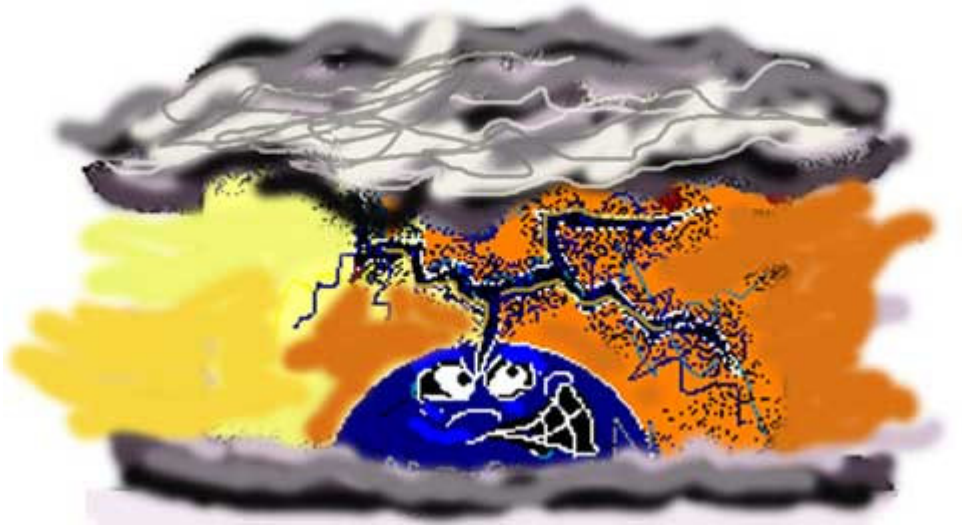
The Shocking Truth About Lightning and Monolithic Domes

May 24, 2004

by David B. South
illustration by Troy Johnson



The ancient Greeks believed that lightning was the wrath of Zeus.The Vikings thought it was produced by Thor riding through the clouds. Some Native American tribes credited lightning to a mystical bird with flashing feathers.

Of course we know better. Science has defined lightning for us. According to a *National Geographic* website, lightning is an electrical discharge between positive and negative regions of a thunderstorm. While there are different kinds of lightning, the most damaging and dangerous kind is cloud-to-ground lightning. Its bolts can have temperatures that are hotter than the sun. More importantly, it's estimated that lightning strikes the earth's surface about 100 times every second. Each year, just in the United States, it kills nearly 100 people, injures many others and damages millions of dollars of property.

So what will lightning do to a Monolithic Dome? Based on the evidence we have gathered so far and on the opinions of experts we have questioned, not much of anything.

In 1979, Boyd and Maxine Stewart moved into the second Monolithic Dome home ever built. Located in Eureka, Kansas -- a thunderstorm-prone area -- their dome has a diameter of 50 feet and a height of 20 feet.

Boyd said that during one severe storm, their dome was hit by a crash of thunder and lightning that seemingly hit at exactly the same moment. Suddenly, lightning lit the inside of the dome, and at the same time a thunder clap was heard.

Boyd knew that lightning had either struck his house or somewhere very near it. He ran outside. Near the dome's top, he saw a thin wisp of smoke. Boyd got a ladder and climbed up for an inspection. He found a charred hole about the size of a finger that had penetrated the Airform and gone into the polyurethane foam insulation. But he could not determine if the concrete was affected as well.

So Boyd simply decided to repair the damage. He got his caulking gun, filled the hole with caulk, and that was the end of that.

In the early eighties, Monolithic built a large church in South Gate, Michigan. Since that area also got many thunderstorms, I consulted a lightning expert at the local power company. I asked this engineer, who worked on lightning directing gears all over the world, if the polyurethane foam would protect the dome. He said, "No" and added that, when it comes to lightning, air is the better insulator.

According to this expert, after lightning travels for several miles through the air, another three inches of foam will not deter it. It's headed for the ground and anything between it and the ground can be struck.

Nor could he see any valid reason for putting a lightning rod on the dome. He said that the lightning rod could act as an attractor, but that did not guarantee that lightning would strike it. Bolts could strike elsewhere.

But what the expert did like about the Monolithic Dome was its rebar cage. He said that the rebar cage gives the dome virtually ultimate protection from lightning. A bolt would enter the rebar cage, follow its connections and travel through it till it reached the footing that goes into the ground. Because the rebar was such a good conductor, any resultant damage would be minimal.

Ten years later, I talked with the maintenance supervisor at that church. He told me that one summer, while they were washing the dome, a worker noticed four holes about the size of a finger. The holes were not causing any leaking, but one did look charred. At first, they thought bullets might have caused the damage, but they knew of no shooting incidents. They then decided that lightning must have been the culprit. Like Boyd Stewart, they repaired the damage by filling the holes with caulking.

In addition to the power company engineer I talked with in South Gate, I have questioned several more experts about the Monolithic Dome's vulnerability to lightning. Their answers are much the same: Lightning strikes will mean virtually nothing to a Monolithic Dome. The bolts will not crack the dome like they often crack power poles or trees or other well-grounded structures. The Monolithic Dome's grounding, provided by its rebar cage, protects it from that kind of serious lightning damage.

Related Links:

- Along the Yellow Brick Road -- The Stewart Home
- Surviving Tornadoes and Hurricanes
- Fire Sprinkler Systems in Monolithic Domes
- Foam As a Fire Hazard
- Foam As a Fire Barrier
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Insurance Rates-- Shop Until They Drop

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Can the annual premium for homeowners insurance on the same Monolithic Dome structure for the same coverage drop from $800 to $174? "Sure can, and did," says Don Tuttle, who, with wife Shirley, built a Monolithic Dome home in Shamrock, Texas just a little over a year ago.

Shamrock, a rural town of about 2500 on Interstate 40, ninety miles east of Amarillo, bills itself as Irish City, USA, the site of an unforgettable St. Patrick's Day Celebration each spring. Legend says that Shamrock got its name in 1898 when a direct representative of St. Patrick decreed that a spot in Texas be named Shamrock, and then mysteriously transported and planted a piece of the Blarney Stone there. A more factual version states that the town got its name from an 1890's railroad site and post office called Shamrock.

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All that, however, is just an amusing side note. What's of interest here at MDI is how and why the Tuttles got a reduction of more than $600 on their homeowner's insurance. The Tuttles' experience happened in Texas, where the Texas Department of Insurance regulates the Texas $37 billion-a-year insurance industry. But MDI believes that what the Tuttles did and the results they got could be duplicated to some significant degree by Monolithic Dome owners in other states.

The Tuttles' 2,600-square-foot home consists of three domes: a 37-foot diameter dome for the kitchen and living areas; two 24-foot diameter domes for bedrooms, bathrooms and office. The fourth dome is used as a garage.

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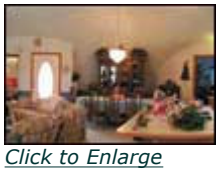
Don says that the insurance company that covered them during the building of the domes decided to drop them after the first year. He unsuccessfully tried to get an explanation for the drop. He says, "The reason was something like-how would you fix the dome should a car or something run into it and knock a hole in it?"

Puzzled but determined, the Tuttles went insurance shopping. After several calls, they found one agent willing to insure the domes, but at an annual premium of $800. So, the shopping continued, until they contacted Noel D. Walton, who has owned and managed Eastern Panhandle Insurance Agency in Shamrock for twenty-one years. "We really do try to help people," Walton says. "Don and Shirley are our neighbors here in town. I just didn't think it was fair or right for their structure to carry any kind of rate comparable to a conventional structure.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"Our main exposure here in Shamrock is hail loss to the roof, and they're not going to have a hail loss to the roof because they don't have a roof," Walton continues. "Their fire risk is potentially zero. They can have a grease fire, or smoke damage, or a dishwasher overflow. Other than that, they don't have much exposure; there's more potential hazard to the contents than the structure."

In most areas, when homeowner's call asking for a price quote for coverage, insurance agents ask certain key questions about the structure's size, age, construction materials, and location. Based on the materials used in its construction, a home in Texas usually falls into one of four categories: frame, stucco, brick veneer, brick.

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Since a Monolithic Dome fits none of those categories, Walton contacted the Texas Department of Insurance for a risk evaluation of the Tuttle residence. "That's part of their function," Walton explains. "If you have a unique risk-a structure that's not your conventional risk because it doesn't fit the established categories-you request the state board to send an inspector out and give that risk a rating."

The Tuttles, armed with blueprints and construction data, met Willard Goss, a Texas Department of Insurance representative. Walton recalls Goss' visit. "He (Goss) was very interested in the construction," Walton says, "and he reviewed all the information Don had ready for him. I thought that Goss was extremely surprised at the structure. Well, once you walk in the door-it's a very warm structure. I felt like it kind of embraced you."

Based on Goss' physical inspection and evaluation, Walton wrote the Tuttles' fire coverage at 60% of the brick premium. "Since the brick rate is best or lowest for residences, the Tuttles pay 60% of the best rate," Walton says. For extended coverage, or damage such as windstorm, hail, hurricane, etc., the Tuttles pay just 10% of the brick premium for the structure and 20% of the brick premium for the contents.

Walton thinks that a Monolithic Dome owner seeking insurance coverage should begin by looking for an agent who really cares, and who will go the extra mile to get the necessary coverage at a fair rate.

Richard Baker, an Inspections Department Manager with the Texas Department of Insurance in Austin, echoes Walton's advice. Baker also suggests that Monolithic Dome owners insist on having their structures evaluated as "noncombustible masonry" and seek help from a state regulatory agency if necessary.

That strategy worked for the Tuttles in Shamrock. The Monolithic Dome Institute thinks it's good advice and a workable plan for just about anywhere-and that's not Blarney!

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